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6.18 TRANSMISSION LINE SYSTEM SAFETY AND NUISANCE

The Project will be connected to an existing 230 kV transmission line in PG&E's electrical transmission line corridor located just west of the Site. This corridor, a major north-south corridor in the San Joaquin Valley, contains two parallel 500 kV lines and one double-circuit 230 kV line. The Project interconnection will consist of approximately 7,000 feet of new double-circuit, 230 kV transmission line extending from the southeast corner of the Site to the PG&E corridor (see Figure 2.1-1).

The analysis of the potential effects from the creation of electric and magnetic fields and interference to radio and television in the following subsections concentrates on the Project interconnection. The effect of the interconnection on the rest of the PG&E system will not exceed the design standards of existing transmission lines, which meet legal requirements, and hence is not discussed.

Beneficial aspects of the Project include:

- The Project is located proximal to a major electrical transmission corridor, so only short segments of new line construction will be required.
- New line construction will occur in an agricultural area, away from homes and other populated areas.
- The Project will use a "loop-in" connection (see Section 2.4 of the Project Description) to interconnect with the existing transmission line. No changes are expected to be necessary at existing substations.

6.18.1 EXISTING CONDITIONS

The Site is located in a rural agricultural region. The closest population center is the business and residential districts of the City of Avenal located approximately 6 miles to the southwest. The farmhouse nearest to the transmission line interconnection is located more than one-half mile from the closest point of the transmission line interconnection. The interconnection crosses open fields planted with orchards and row crops.

6.18.1.1 Existing Offsite Transmission Lines and Substations

One Gates-Midway 500 kV line, one Los Banos-Midway 500 kV line and one Gates-ARCO 230 kV line are located on the PG&E right-of-way that passes less than 1 mile to the west of the Site. The portion of the Gates-ARCO 230 kV line between the Gates substation and the Project

interconnection point consists of two 795 kcmil ACSR conductors per phase capable of carrying about 592 MW of power at a wind velocity of 2 feet per second.

The Project will interconnect by looping the existing PG&E Gates-ARCO 230 kV line into the Site, using a new double circuit line constructed from the PG&E corridor to the Site. This new double circuit 230 kV line will be routed from the southeast corner of the Site to the existing Gates-ARCO 230 kV line as shown in Figure 2.1-1. This new 230 kV double circuit line will be constructed on a 120 foot wide ROW. Figure 2.4-2 shows the PG&E Gates-Midway transmission system (230 kV and above). Figure 2.4-5 shows the routing of the existing transmission lines in the vicinity of the Site and the short line addition required to loop the Gates-ARCO 230 kV line into the Site switchyard.

The PG&E Gates substation, located about 5 miles northwest of the Site (see Figure 2.4-1), includes a 500 kV switchyard, 500 to 230 kV transformers, and 230 kV and 70 kV switchyards. The 230 kV line that the Project will be connected to provides power to the greater Fresno and San Joaquin Valley areas. ARCO is a 230/70 kV substation supplying mostly agricultural and oil extraction and refining load. The distance from Gates to ARCO is approximately 34 miles. The first approximately 27 miles south of Gates are essentially a bundled circuit; the line is formed from two previously independent circuits, tied together to operate as a single, higher capacity circuit. There is a loop into ARCO with a remaining distance of approximately 7 miles, which makes the entire Gates-ARCO distance approximately 34 miles. It is about 44 miles from Midway to Arco, with the entire circuit being a single 795-kcmil ACSR conductor.

6.18.1.2 Audible Noise and Radio/Television Interference

When a transmission line is in operation, an electric field is generated in the air surrounding the conductor. The electric field causes a partial breakdown of the insulating properties of the air in the vicinity of the conductors that is called a corona. When the intensity of the electric field at the conductor surface exceeds the breakdown strength of the surrounding air, a corona discharge occurs at the conductor surface. Energy and heat are dissipated in small volumes near the surface of the conductors. Part of this energy is in the form of small local pressure changes that result in audible noise or in a discharge that results in radio/television (TV) interference.

Corona-generated audible noise can be characterized as a hissing, cracking sound which, under certain conditions, is accompanied by a 120-hertz (Hz) hum. Corona-generated audible noise is of concern primarily for lines at voltages of 345 kV and higher. Although the conductors of high

voltage transmission lines are designed to be essentially corona-free under ideal conditions, slight variations and irregularities in the conductor surface cause higher electric fields near the conductor surface and the occurrence of corona. The most common source of higher electric fields at the conductor surface is water droplets on, or dripping from, the conductors. Therefore, audible noise from transmission lines is generally associated with wet weather and wet conductors. Wet conductors can occur during periods of rain, fog, snow or icing. These conditions are expected to occur infrequently in the vicinity of the Project. During fair weather, insects and dust on the conductor also can serve as causes of corona.

Corona on transmission line conductors also can generate electromagnetic noise in the frequency bands used for radio and TV signals. Radio and TV interference, known as gap-type noise, is caused by an oxidized film on the surface of two hardware pieces in contact. The film acts as an insulator between the surfaces and generates small electric arcs, which produce noise and interference.

Interference with electromagnetic signals by corona-generated noise, particularly interference with TV signals, is generally associated with lines operating at voltages of 345 kV or higher, or with lines that are not well maintained.

Whether a particular level of radio or TV noise will cause unacceptable reception depends on what is perceived to be acceptable. Acceptable reception is affected both by ambient noise levels and the strength of the radio or TV signal received. One measure of the acceptability of radio or TV noise is the signal-to-noise ratio, defined as the ratio of the average signal power to the average noise power. A signal-to-noise ratio above 20 is generally considered to provide acceptable radio reception, and a signal-to-noise ratio of 30 to 40 will generally provide acceptable TV reception.

The two PG&E 500 kV transmission lines and one 230 kV line in the corridor to the west of the Site are currently maintained by well-trained experienced transmission line crews. If complaints of noise and radio or TV interference are received, they are logged, investigated and corrected by PG&E.

6.18.1.3 Induced Currents and Hazardous/Nuisance Shocks

Induced current or spark discharge shocks can occur under certain conditions, in electric fields created by 230 kV or higher voltage transmission lines, when a person comes into contact with

an object in an electric field. While these shocks are a nuisance associated with electric fields, studies indicate they will not produce long-term health effects. The potential for incurring electric field shocks can be reduced by grounding all metal objects near transmission lines. There have been no reports of electric field shocks from the transmission lines in the corridor west of the Site.

6.18.1.4 Electric and Magnetic Fields

Whenever electricity is used or transmitted, electric and magnetic fields (EMFs) are created. An electric field exists in a region of space if a free charge, at rest in that space, experiences a force of electrical origin tending to cause the free charge to move. The electric field is a vector quantity; that is, it has both magnitude and direction. The direction corresponds to the direction a positive charge would move in the field. Sources of electric fields are unbalanced electrical charges (positive or negative) and time-varying magnetic fields. Transmission lines, distribution lines, house wiring and appliances all generate electric fields in their vicinity because of unbalanced electrical charges on unshielded conductors. Electric fields are expressed in units of volts per meter (V/m) or kilovolts (thousands of volts) per meter (kV/m). Electric fields are easily shielded by most objects, including trees, fences and buildings.

Once electric fields are in motion, they create magnetic fields. Electric currents also create magnetic fields, and the strength of the magnetic field is proportional to the magnitude of the current in the circuit. Magnetic fields can be characterized by the force they exert on a moving charge or on an electrical current. Magnetic field is a vector quantity that is characterized by both magnitude and direction. Magnetic fields are expressed as exposure per unit area in units of milligauss (mG). Magnetic fields are not shielded by most materials.

The spatial uniformity of an electric field depends on the source of the field and on the distance from that source. On the ground under a transmission line, the electric field is nearly constant in magnitude and direction over distances of a few meters. In proximity to transmission or distribution line conductors, however, the field decreases rapidly as distance (r) from the conductor increases. If an energized conductor (source) is inside a grounded conducting

enclosure, then the electric field outside the enclosure is zero, and the source is said to be shielded.

Transmission line-related fields decrease at a rate of $1/r^2$ if currents are balanced and conductors are closely spaced. Magnetic fields associated with unbalanced phase circuits will fall off inversely from distance to the source (conductor) at a rate of $1/r$. Therefore, if the distance is doubled from the source and the transmission line current is balanced in all three phases, the magnetic field will drop off by a factor of four. However, if the phase current is unbalanced and distance from the source is doubled, the field decreases by only one-half of its original intensity.

The electric field created by a high voltage transmission line extends from the energized conductors to other conducting objects such as the ground, towers, vegetation, buildings, vehicles and people. The strength of the vertical component of the electric field at a height of 1 meter (3.28 feet) is frequently used to describe the electric field under transmission lines. Magnetic fields from high voltage transmission lines are produced only when current flows, and they have a magnitude that is dependent on the amount of current, not the applied voltage.

The most important parameters of a transmission line in determining EMF at a 1-meter height are conductor height above ground and line voltage. The maximum, or peak, EMF occurs in areas near the centerline and at midspan, where conductors are at their lowest point.

6.18.1.5 Electric and Magnetic Field Modeling

The BPA Program model was used to calculate the electric and magnetic fields for the new 230 kV DCTL that will connect the Site switchyard to the existing PG&E 230 kV line. The BPA Program is used to predict values of electric and magnetic fields, and predicted values have been confirmed based on field measurements by numerous utilities. To estimate the maximum EMF, calculations are performed at mid-span where the conductor is at its lowest point between structures, and at a height of 1 meter above ground. The calculations and methodology are included in Appendix 6.18-1.

6.18.1.6 EMF Consensus Group Finding

In January 1991, the California Public Utilities Commission (CPUC) issued an Order Instituting Investigation (CPUC, 1991) into the potential health effects from electric and magnetic fields emitted by electric power and cellular telephone facilities. In September 1991, the assigned CPUC administrative law judge issued a ruling that created the "California EMF Consensus Group." This group of representatives from utilities, industry, government, private and public research, and labor organizations submitted a document entitled "Issues and Recommendations for Interim Response and Policy Regarding Power Frequency EMFs" on March 20, 1992 (California EMF Consensus Group, 1992). Regarding the relevant policy consensus recommendation titled "Facility Siting," the group stated the CPUC should recommend that utilities take public concern about EMFs into account when siting new electric facilities. This group could not conclude that there is a relationship between EMF and human health effects and recommended the CPUC authorize further research.

6.18.2 IMPACTS

6.18.2.1 Significance Criteria

Significance criteria were determined based on CEQA Guidelines, Appendix G, Environmental Checklist Form (approved December 1, 1999) and on performance standards or thresholds adopted by responsible agencies. An impact may be considered significant if the Project results in:

- Increased levels of audible noise and radio/TV interference.
- Significant changes to the existing electric and magnetic fields.
- Changes to the configuration or operation of the transmission system such that new transmission lines or switchyards would be required to be constructed.

A preliminary assessment of the ability of the PG&E 230 kV transmission line to accommodate the 600 MW of additional power from the Project has been completed. Preliminary evaluations indicate that the PG&E transmission system will not require construction of new switchyards or transmission lines. A new switchyard will be constructed at the Site to collect the power from the generating units for delivery to the grid via the future Avenal-Gates and Avenal-ARCO lines.

Preliminary power flows are provided in Appendix 6.18.2 (confidential filing). These resulting currents were used to calculate expected electric and electromagnetic fields reported in this section. The currents obtained through power flow runs are summarized in Appendix 6.18.1.

6.18.2.2 Audible Noise and Radio/Television Interference

The intensity of noise levels and potential for radio and TV interference from transmission lines are related to the corona performance of the lines. Corona performance can be predicted using empirical equations that have been developed from measurements on several high-voltage lines. The BPA Program utilizes an empirical equivalent method to analyze corona performance that agrees with long-term data. Outputs of the program are maximum conductor surface voltage gradient, fair and foul weather audible noise, and radio and TV interference levels at the ROW edges. These outputs are indices of corona performance.

The BPA Program was used to assess the potential impacts of the approximately 7,000 feet of new 230 kV line from the Project to the existing PG&E 230 kV line in the corridor. The model output results are shown in Appendix 6.18-1.

Noise is measured on a logarithmic scale, expressed in dB. For the new interconnecting line, the predicted fair weather audible noise levels range from a maximum of 5.7 decibels on the A-weighted scale (dBA) to 4.7 dBA at the ROW edges (see Appendix 6.18-1). The A-weighted scale is the most widely used scale for describing noise levels because it correlates with human response to sound. There are generally few complaints about transmission line noise for levels below 50 dBA (Electric Power Research Institute, 1987).

The addition of the Project will not change the values of the corona performance indices for the three existing PG&E transmission lines modeled in this analysis and the corona performance of the new 7,000-foot interconnecting line is acceptable (see Appendix 6.18-1). Therefore, there are no predicted impacts to current audible noise and radio and TV interference levels due to the Project.

6.18.2.3 Electric and Magnetic Fields

The potential impacts of the Project's new line were modeled using the BPA Program, as described in Appendix 6.18-1. Table 6.18-1 shows the EMF modeling results for the new 230 kV interconnection line. The electric field at the midpoint of the new interconnection line also is shown. The maximum modeled electric field strength within the ROW is 3.309 kV/M; the value at the edges of the ROW is 0.531 kV/M. While California does not have a regulatory level, these values are within levels established by those states that do have regulatory limits.

TABLE 6.18-1

**ELECTRIC FIELD VALUES (KILOVOLTS/METER)
AND MAGNETIC FIELD VALUES (MILLIGAUSS)
FOR THE NEW 230 KV INTERCONNECTION**

LOCATION ⁽¹⁾	ELECTRIC FIELD (kV/M)	ELECTROMAGNETIC FIELD (mG)
Left ROW Edge	0.531	80.30
Maximum	3.309	182.92
Right ROW Edge	0.531	29.77

⁽¹⁾ See Appendix 6.18-1 for ROW location.

States with regulations have ranges from 1.0 kV/M to 2.0 kV/M at the edge of the ROW, depending on line voltage. The Commission does not presently specify limits on electric fields (Commission, 1992).

The magnetic field strength values range from 80.3 mg and 29.77 mg at the edge of the ROWs, and from 33.12 to 182.92 mg within the ROW. While California does not have a regulatory level, these values are well below the levels established by those states that do have regulatory limits. States with regulations have ranges from 150 mg to 250 mg at the edge of the ROW, depending on line voltage. The Commission does not presently specify limits on magnetic fields, but does require measurement and reporting of levels along ROWs for lines licensed by the Commission (Commission, 1992).

6.18.2.4 Cumulative Impacts

None of the offsite cumulative projects (see Table 6.1-1) will alter transmission line voltage. Consequently, there are no cumulative transmission system impacts associated with the Project.

6.18.2.5 Project Design Features to Avoid or Minimize Impacts

The following design features minimize electrical transmission system safety and nuisance impacts of the Project:

- The Project is located proximal to a major electrical transmission corridor, so only a short segment of new line construction will be required.
- New line construction will occur in an agricultural area away from homes and other populated areas.

6.18.3 MITIGATION MEASURES

The Project will not result in a significant impact. As a result, no mitigation measures are required.

6.18.4 SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There are no significant unavoidable adverse impacts associated with the Project.

6.18.5 LAWS, ORDINANCES, REGULATIONS AND STANDARDS (LORS)

A list of applicable LORS that apply to Corona and interference with radio and television signals is shown in Table 6.18-2. No permits outside the authority of the commission are required for transmission line safety and nuisance. Agency contacts are provided in Chapter 2.0 – Project Description, Table 2.5-5.

6.18.6 REFERENCES

California EMF Consensus Group. Issues and Recommendations for Interim Response and Policy Regarding Power Frequency EMFs. 1992.

California Energy Commission (Commission). High Voltage Transmission Lines, Summary of Health Effects Studies. 1992.

California Public Utilities Commission (CPUC). Order Instituting Investigation (I.91-01-0120). 1991.

Electric Power Research Institute (EPRI). Transmission Line Reference Book, 115-138 kV. 1978.

EPRI. Transmission Line Reference Book, 345-kV and Above. 1975.

EPRI. Transmission Line Reference Book, 345 kV and Above. 1987.

PG&E. Interconnection Handbook, PG&E. December 15, 1998.

TABLE 6.18-2**TRANSMISSION LINE SYSTEM SAFETY AND NUISANCE LORS AND COMPLIANCE**

JURIS-DICTION	AUTHORITY	ADMINISTERING AGENCY ⁽¹⁾	REQUIREMENTS/ COMPLIANCE	APPROACH TO COMPLIANCE	AFC SECTION
Federal	Federal Communications Commission Regulations, 47 CFR §15.25, Operating Requirements, Incidental Radiation.	Federal Aviation Administration (FAA).	Mitigation for any device that causes communications interference.	The Project will not cause communications interference.	Section 6.18 - Transmission Systems Safety and Nuisance; Section 2.4 - Transmission Lines Description, Design and Operation; Sections 6.18.1, 6.18.2 Pages 6.18-1 through 6.18-9 Appendix 6.18-1
	Federal Aviation Administration, 14 CFR 77; AC No. 70/460-1G.	FAA.	Describes standards for marking and lighting objects.	The Project design includes lighting and visibility measures for tall structures that may pose a navigation hazard.	6.9.3.4, 6.9.3.6 Pages 6.9-22, 6.9-23, 6.9-24
State	CPUC, General Order 52 Construction and Operation of Power and Communication Lines.	California Public Utilities Commission.	Prevent or mitigate inductive interference.	The Project electrical interconnection will conform to requirements of this order.	6.18.1.4, 6.18.1.5, 6.18.2.3 Pages 6.18-4, 6.18-7, 6.18-8 Appendix 6.18-1
	3 CCR §2700 et seq., High Voltage Electric Safety Orders.	California Public Utilities Commission.	Compliance with standards for operation and maintenance of electrical equipment.	The Project electrical interconnection will conform to requirements of this regulation.	6.18.1, 6.18.2 Page 6.18-1 through 6.18-9
	Radio & Television Interference (RI/TVI) Criteria.	California Energy Commission.	RI/TVI mitigation requirements, if applicable.	No radio or TV interference is expected.	6.18.2.2 Page 6.18-7 Appendix 6.18-1
Local	None applicable.	None applicable.	None applicable.	Not Applicable.	None applicable.
Industry	Bonneville Power Administration (BPA), Corona and Field Effects Program Version 3.	None applicable.	Electric and magnetic fields and corona effects modeling.	This model was used to assess project impacts.	6.18.1.2, 6.18.1.4, 6.18.1.5, 6.18.2.2, 6.18.2.3 Pages 6.18-2 through 6.18-5, 6.18-7, 6.18-8 Appendix 6.18-1
	California Independent System Operator (Cal-ISO).	Cal-ISO as reviewer.	Review interconnection study.	The PG&E Interconnection Study conforms with this requirement.	2.4.5 Page 2-103 Appendix 6.18-2 (confidential filing)
	National Electrical Safety Code Part 2.	None applicable.	Provides guidelines for safe operating clearances.	The interconnection will be designed to conform with this requirement.	2.4 Pages 2-89 through 2-104

31161/Avenal/Tbls&Figs (10/5/01/jb)

⁽¹⁾ Pursuant to CCR Title 20, Appendix B(h)(1)(B): Each agency with jurisdiction to issue applicable permits and approvals or to enforce identified laws, regulations, standards, and adopted local, regional, state, and federal land use plans, and agencies which would have permit approval or enforcement authority, but for the exclusive authority of the Commission to certify sites and related facilities.